Comparing the Costs of HIV Screening Strategies and Technologies in Health-Care Settings

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SYNOPSIS

Objectives. In 2006, the Centers for Disease Control and Prevention (CDC) recommended routine human immunodeficiency virus (HIV) screening for people aged 13 to 64 years in all U.S. health-care settings. Earlier recommendations focused on those at high risk for HIV and included more extensive pretest counseling. HIV screening may also involve either rapid or conventional testing. The purpose of this research was to estimate the costs of these different testing procedures and the cost per HIV-infected patient correctly receiving test results in three health-care scenarios that illustrated these policy differences.

Methods. The study estimated the costs of rapid and conventional HIV testing in the following scenarios: (*1*) sexually transmitted disease (STD) clinic counseling and testing (CT), (*2*) STD clinic screening, and (*3*) emergency department (ED) screening. Costs were estimated from the provider perspective in 2006 dollars. A decision analytic model was developed to estimate the cost per HIV-infected patient notified of test results using the two testing procedures in the three scenarios.

Results. Although the complete rapid testing procedure was more expensive than conventional testing, the cost per HIV-infected patient receiving test results was lower for the rapid test compared with conventional testing in all scenarios. Per-patient costs of receiving results were lowest in the ED screening scenario and highest in the STD CT scenario. These costs were sensitive to changes in test costs, HIV prevalence, and return rates following conventional tests.

Conclusion. HIV screening in general health-care settings is economically feasible, particularly with rapid tests that lower the cost of HIV-infected patients receiving their test results.

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In September 2006, the Centers for Disease Control and Prevention (CDC) issued revised recommendations advocating voluntary human immunodeficiency virus (HIV) screening for all patients aged 13 to 64 years as a normal part of medical practice in health-care settings including hospitals, acute-care clinics, and sexually transmitted disease (STD) clinics, unless the prevalence of undiagnosed HIV infection has been documented to be less than 0.1%.[1] This policy contrasted with previous recommendations for routine counseling and testing for people at high risk for HIV and for those in acute-care settings in which HIV prevalence was greater than 1%.[2,3] The earlier policy involved the provision of counseling and testing after patients gave specific informed consent for an HIV test.

An estimated 25% of people infected with HIV are unaware they are infected.[4] The goals of the new CDC recommendations are to increase the number of people aware of their infection through routine testing and to link them with appropriate care and treatment.[5] Testing based on risk assessment often fails to identify many infected people.[6] Also, people aware of their infection are likely to change their behaviors and reduce the risk of infecting others.[7] Because extensive pretest prevention counseling and written informed consent specifically for an HIV test sometimes posed barriers to testing, a streamlined screening strategy was recommended. With this approach, patients are informed that an HIV test will be performed unless they decline, and information about HIV infection is often provided in writing. Consent for HIV testing is included in the general informed consent for medical care.

Concurrently, HIV screening has increasingly used rapid tests that provide test results during the same health-care visit.[8,9] Compared with conventional testing with an enzyme immunoassay (EIA), rapid tests increase (by a factor of 1.5 to 2.2) the likelihood that both HIV-infected and uninfected patients receive their test results, because the results are delivered during the initial visit.[10] However, rapid tests typically cost more to perform than conventional tests.

The purpose of this research was to estimate the costs of conventional and rapid HIV testing in three scenarios to illustrate the differences among testing strategies and technologies. This article presents new estimates of the costs of the conventional and rapid testing procedures in these different scenarios. Previous economic analyses of rapid HIV tests used a test that is more difficult to perform and no longer on the market.[11,12] The current study also estimates the cost per HIV-infected patient correctly notified of his/her test result. This cost estimate adjusts the initial costs for the likelihood of patients participating in the process and returning for and receiving correct test results.

The settings analyzed in this study—STD clinics and emergency departments (EDs)—are also relevant to the issue of increasing testing in minority communities, given the significant number of minority patients receiving services in these settings and the proportion of minorities that are estimated to be infected with HIV but unaware of their status.[6,13–15] During 2001–2005, black people accounted for 51.0% of newly diagnosed HIV infections, and the greatest proportion of cases (48.0% and 47.4%, respectively) were among people aged 25 to 34 and 35 to 44 years.[16]

METHODS

Actual costs, not charges, were estimated from the provider perspective. Input variables, including costs and probabilities of patients completing various parts of the testing process, were derived from both the literature and various CDC-funded HIV counseling and testing projects. The study includes values for provider time as well as costs of materials and test kits used. The analysis was conducted using TreeAge Pro 2005 software.[17]

This article compares the costs of rapid and conventional HIV testing in two health-care settings: STD clinics and EDs. In the STD setting, the counseling and testing (CT) approach was contrasted with the screening approach of testing only. Because the time constraints of client-centered pretest counseling make widespread adoption of the CT approach unlikely in EDs, only the screening approach was analyzed in the ED setting.

Testing procedure

The conventional HIV testing procedure involves phlebotomy and submission of a serum specimen to a central laboratory for processing. Patients must return to receive their test results and posttest counseling during a second visit. A specimen negative by EIA requires no further testing. A reactive EIA is repeated in duplicate and followed by a confirmatory Western blot test. Thus, conventional testing is a one-test sequence for negative EIA results, but a four-test sequence for reactive EIA results.

Current point-of-care rapid tests use either a fingerstick blood or oral-fluid swab specimen.[8] Test results are typically provided within 30 minutes. Patients who test negative are given their results with brief posttest counseling. If the rapid test is reactive, the patient is told that he/she may be infected with HIV and is given more

extensive posttest counseling that discusses the meaning of the reactive test, the need for a confirmatory test and a return visit, and the need for risk-reduction behaviors while awaiting the results of confirmatory testing.[8] Blood is drawn for the confirmatory Western blot, and the patient is scheduled for a return visit for test results and further posttest counseling. Thus, rapid testing involves a one-test sequence for negative test results, but a two-test sequence for reactive results.

Three scenarios

The STD Clinic, CT scenario, is based on the earlier CDC recommendations.[2,3] Patients whose behavior puts them at high risk for HIV may go to an STD clinic. The patient is offered an HIV test and decides whether to accept. Everyone who accepts HIV testing is given client-centered pretest prevention counseling as defined by CDC. This is an interactive process involving risk assessment and development of a plan to reduce risky behaviors that is consistent with pretest counseling in STD clinics as implemented in Project RESPECT[18] and RESPECT 2.[19] Patients are asked to provide written consent specifically for an HIV test.

In the STD Clinic, Screening scenario, patients attending the STD clinic are given an HIV test as part of standard practice unless they decline. Patients are given only limited verbal or written information about HIV infection, HIV testing, and interpretation of test results.

The ED Screening scenario assumes that patients go to an ED for a condition unrelated to HIV. As part of the standard course of treatment, patients are given an HIV test unless they decline. Written information about the HIV test and its implications is provided.

Decision tree

The decision tree for estimating the cost per HIV-infected patient correctly notified of his/her test result with conventional and rapid tests is shown for the STD clinic, CT scenario (Figure). The structure of the tree is similar for the other two scenarios, although the input values are different.

Input variables

Table 1 lists the input variables for each scenario. Only variable costs were included in the analysis; fixed costs were not considered. All costs were reported in 2006 dollars. Wage rates were assumed to be the same in all scenarios, but the duration of pre- and posttest counseling depended on the approach (CT vs. screening) and the setting (STD clinic vs. ED). We assumed that a substance abuse or HIV testing counselor would provide counseling. We assumed no pretest counseling or administrative staff time in the STD and ED screening scenarios because, with screening, information about testing is often posted on signs or provided in pamphlets, and responses are documented only when a patient declines testing. No more administrative time was spent on HIV screening than that devoted to the patient's primary reason for presentation at the health-care venue.

The baseline probabilities for estimating the cost per HIV-infected patient correctly notified of his/her result in the three scenarios (Table 2) correspond to the chance nodes in the Figure. Test acceptance and return rates were drawn from the literature.[10,20,21] Acceptance rates, based on eight years of clinical data from the Texas STD program and emergency room studies, included both eligibility and acceptance. With the rapid test, all patients were assumed to receive their test results during the first visit. An HIV prevalence observed in similar settings (1%) was used in the base case model.[22]

Outcome measures

Outcome measures are the cost per patient completing the entire conventional or rapid testing procedures and the cost per HIV-infected patient correctly notified of his/her HIV test result in the three scenarios. To calculate the latter with the decision tree, a final value of one was assigned to HIV-infected patients who correctly learned their confirmed test results and a value of zero to patients who failed to receive their test results or who received incorrect results. For the rapid test, there was a question of how to value the outcomes of those patients who, on the first visit, received the information that they may be infected, but failed to return for confirmatory test results. Given the accuracy of HIV screening tests, the information and counseling provided for these infected patients at the first visit was valued as nearly equivalent to receiving the confirmatory information. An outcome value of 0.99 was assigned to such patients,[11] and the impact of this assumption was tested in the sensitivity analysis.

Sensitivity analysis

Sensitivity analysis was performed on the input cost and probability variables affecting the cost per HIV-infected patient receiving test results. HIV prevalence varied from 0.001 to 0.04, the probabilities of accepting testing and counseling and returning for test results varied from 0.1 to 1.0, the EIA reagent cost varied from $0.10 to $15.00, and the rapid test kit cost varied from $1.00 to $15.00. Threshold levels of the input variables

Figure. Decision tree comparing conventional and rapid HIV tests

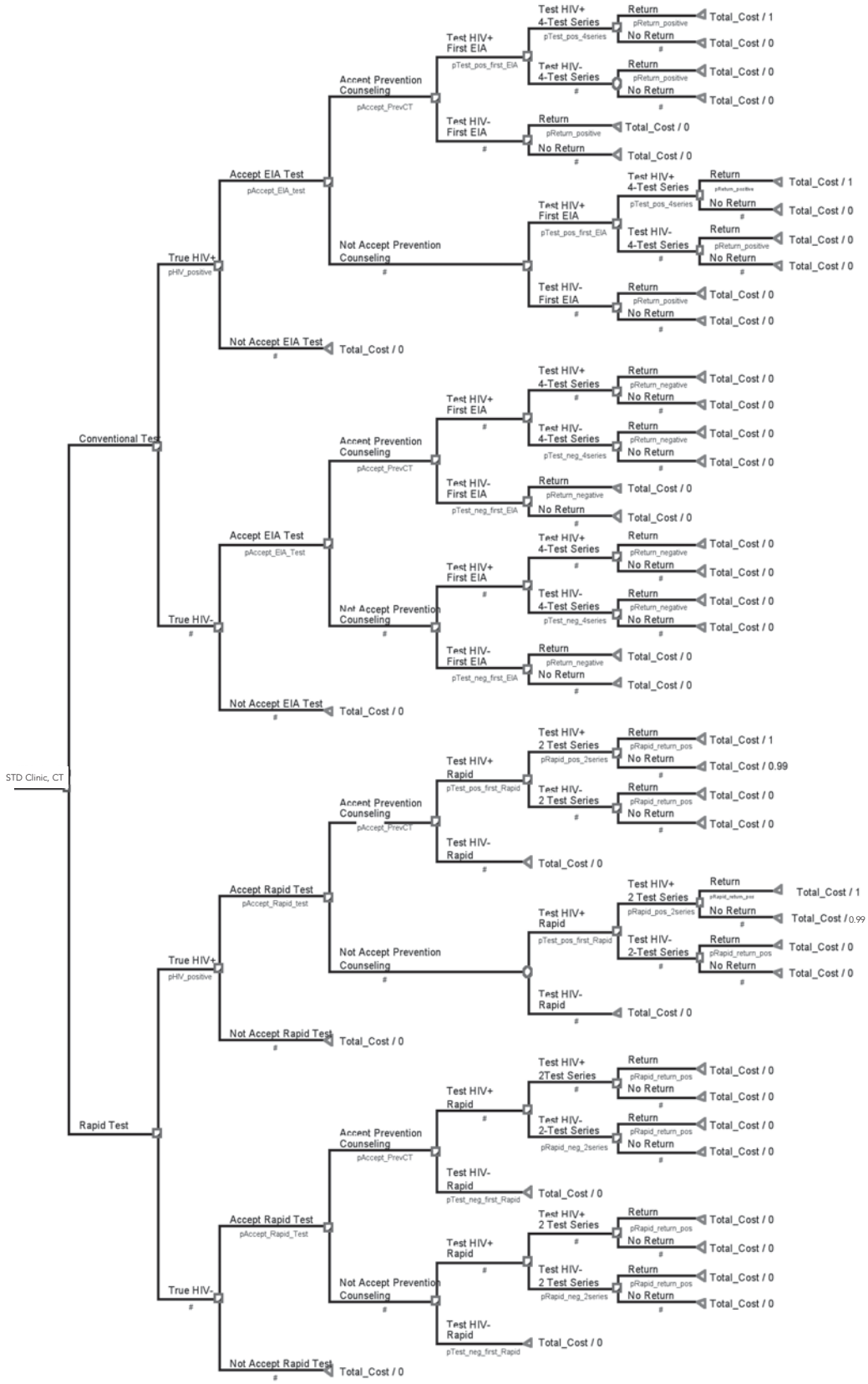

Table 1. Input variables for the cost analysis of three HIV testing scenarios (in 2006 dollars)

Variable	*STD CT*		*STD Screening*		*ED Screening*	
Conventional test procedure	*HIV+*	*HIV−*	*HIV+*	*HIV−*	*HIV+*	*HIV−*
Pretest counseling, first visit						
Wage rate/hour, provider, pretest counseling[a]	$17.28	$17.28	$17.28	$17.28	$17.28	$17.28
Provider time, pretest counseling (in hours)[b,c]	0.40	0.40	0.00	0.00	0.00	0.00
Wage rate/hour, provider collecting specimen[a]	$17.28	$17.28	$17.28	$17.28	$17.28	$17.28
Provider time, collecting specimen (in hours)[d]	0.09	0.09	0.09	0.09	0.09	0.09
Wage rate/hour, administrative staff[e]	$14.07	$14.07	$14.07	$14.07	$14.07	$14.07
Administrative staff time (in hours)[f]	0.25	0.25	0.00	0.00	0.00	0.00
HIV antibody testing						
Wage rate/hour, lab technician, EIA[g]	$16.65	$16.65	$16.65	$16.65	$16.65	$16.65
Provider time, EIA test(s) (in hours)[h,i]	0.0456	0.0228	0.0456	0.0228	0.0456	0.0228
Wage rate/hour, lab technician, WB[g]	$16.65	$16.65	$16.65	$16.65	$16.65	$16.65
Provider time, WB test (in hours)[h,j]	0.168	0.00	0.168	0.00	0.168	0.00
Cost of EIA reagent[h,k]	$13.05	$4.35	$13.05	$4.35	$13.05	$4.35
Cost of WB test kit[h]	$35.11	$0.00	$35.11	$0.00	$35.11	$0.00
Posttest counseling, second visit						
Wage rate, provider, posttest counseling[a]	$17.28	$17.28	$17.28	$17.28	$17.28	$17.28
Provider time, posttest counseling (in hours)[b,l]	0.55	0.185	0.55	0.185	0.24	0.02
Wage rate/hour, administrative staff[e]	$14.07	$14.07	$14.07	$14.07	$14.07	$14.07
Administrative staff time (in hours)[f]	0.25	0.25	0.25	0.25	0.25	0.25
Variable	*STD CT*		*STD Screening*		*ED Screening*	
Rapid test procedure	*HIV+*	*HIV−*	*HIV+*	*HIV−*	*HIV+*	*HIV−*
Pretest counseling, first visit						
Wage rate/hour, provider, pretest counseling[a]	$17.28	$17.28	$17.28	$17.28	$17.28	$17.28
Provider time, pretest counseling (in hours)[b,c]	0.40	0.40	0.00	0.00	0.00	0.00
Wage rate/hour, provider collecting specimen[a]	$17.28	$17.28	$17.28	$17.28	$17.28	$17.28
Provider time, collecting specimen (in hours)[b,m]	0.14	0.05	0.14	0.05	0.14	0.05
Wage rate/hour, administrative staff[e]	$14.07	$14.07	$14.07	$14.07	$14.07	$14.07
Administrative staff time (in hours)[f]	0.25	0.25	0.00	0.00	0.00	0.00
HIV antibody testing						
Wage rate/hour, lab technician, rapid test[a]	$17.28	$17.28	$17.28	$17.28	$17.28	$17.28
Provider time, rapid test (in hours)[b,n]	0.06	0.06	0.06	0.06	0.06	0.06
Wage rate/hour, lab technician, WB[g]	$16.65	$16.65	$16.65	$16.65	$16.65	$16.65
Provider time, WB test (in hours)[h,j]	0.168	0.00	0.168	0.00	0.168	0.00
Cost of rapid test kit[o]	$ 9.00	$ 9.00	$ 9.00	$ 9.00	$ 9.00	$ 9.00
Cost of WB test kit[h]	$35.11	$0.00	$35.11	$0.00	$35.11	$0.00
Posttest counseling, first visit						
Wage rate/hour, provider, posttest counseling[a]	$17.28	$17.28	$17.28	$17.28	$17.28	$17.28
Provider time, posttest counseling (in hours)[b,l]	0.55	0.185	0.55	0.185	0.24	0.02
Wage rate/hour, administrative staff[e]	$14.07	$14.07	$14.07	$14.07	$14.07	$14.07
Administrative staff time (in hours)[f]	0.25	0.25	0.25	0.25	0.25	0.25

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Table 1 (continued). Input variables for the cost analysis of three HIV testing scenarios (in 2006 dollars)

Variable	*STD CT*		*STD Screening*		*ED Screening*	
Rapid test procedure	*HIV+*	*HIV−*	*HIV+*	*HIV−*	*HIV+*	*HIV−*
Posttest counseling, second visit						
Wage rate/hour, provider, posttest counseling[a]	$17.28	$17.28	$17.28	$17.28	$17.28	$17.28
Provider time, posttest counseling (in hours)[b,l]	0.55	0.00	0.55	0.00	0.24	0.00
Wage rate/hour, administrative staff[e]	$14.07	$14.07	$14.07	$14.07	$14.07	$14.07
Administrative staff time (in hours)[f]	0.25	0.00	0.25	0.00	0.25	0.00

[a]Department of Labor, Bureau of Labor Statistics (US). Occupational employment and wages, May 2006: 21-1011, substance abuse and behavioral disorder counselors: mean hourly wage [cited 2007 May 20]. Available from: URL: http://www.bls.gov/oes/2006/may/oes211011.htm

[b]Silva A, Glick NR, Lyss SB, Hutchinson AB, Gift TL, Pealer LN, et al. Implementing an HIV and sexually transmitted disease screening program in an emergency department. Ann Emerg Med 2007;49:564-72. Additional time and motion data from study authors were also used.

[c]Client-centered counseling time consistent with CDC definitions was 21 minutes; time for consent and explanation of Health Insurance Portability and Accountability Act requirements was 2.03 minutes; time for describing and offering testing was 1.11 minutes. The total time was 24.l4 minutes, or 0.40 hour. Our study assumed there was no pretest counseling for the STD Screening and ED Screening scenarios.

[d]Provider time for collecting the specimen of 5.47 minutes or 0.09 hour was derived from a national commercial testing laboratory.

[e]Department of Labor, Bureau of Labor Statistics (US). Occupational employment and wages, May 2006: 43-9199, office and administrative support workers, all other: mean hourly wage [cited 2007 May 20]. Available from: URL: http://www.bls.gov/oes/2006/may/oes439199.htm

[f]Ekwueme DU, Pinkerton SD, Holtgrave DR, Branson BM. Cost comparisons of three HIV counseling and testing technologies. Am J Prev Med 2003;25:112-21. Our study assumed there was no additional administrative staff time for pretest counseling for the STD Screening and ED Screening scenarios beyond that necessary for the primary reason for the patient's visit. Provider and administrative staff times for posttest counseling on the second visit for the conventional test procedure were assumed to be equal to that of the first visit for the rapid test procedure.

[g]Department of Labor, Bureau of Labor Statistics (US). Occupational employment and wages, May 2006: 29-2102, medical and clinical laboratory technicians: mean hourly wage [cited 2007 May 20]. Available from: URL: http://www.bls.gov/oes/2006/may/oes292012.htm

[h]Data obtained from a national commercial testing laboratory.

[i]Our study assumed 0.57 effort/day×8 hours/200 tests/day=0.228 hour for one test for an HIV-negative result. This time was multiplied by two for an HIV-positive test result because the test was repeated in duplicate.

[j]Our study assumed 0.42 effort/day×8 hours/20 tests/day=0.168 hour. This applied to reactive EIA results only.

[k]The cost for an HIV-negative result ($4.35) was multiplied by three for an HIV-positive result because an initial reactive EIA was repeated twice.

[l]STD CT and STD Screening scenarios: CDC unpublished data. ED Screening scenario: Lyss SB, Branson BM, Kroc KA, Couture EF, Newman DR, Weinstein RA. Detecting unsuspected HIV infection with a rapid whole-blood HIV test in an urban emergency department. J Acquir Immune Defic Syndr 2007;44:435-42. Under the rapid test procedure, people who tested negative on the rapid screening test did not return to the testing site.

[m]The time for a finger stick for an HIV-uninfected person=2.73 minutes, or 0.05 hour. For an HIV-infected person, we added phlebotomy time of 5.47 minutes for the WB test; total time: 2.73+5.47=8.20 minutes, or 0.14 hour.

[n]Total time is 6.11 minutes minus 2.73 minutes for the finger stick=3.38 minutes, or 0.06 hour.

[o]General Services Administration (US). GSA schedule for rapid test cost [cited 2007 May 2]. Available from: URL: https://www.gsaadvantage.gov/advgsa/advantage/search/search.do?query=hiv+rapid+test. Cost was $8.00 for the Unigold test and $11.00 for the OraQuick test, so $9.00 was used as a mean.

HIV = human immunodeficiency virus

STD = sexually transmitted disease

CT = counseling and testing

ED = emergency department

EIA = enzyme immunoassay

WB = Western blot

CDC = Centers for Disease Control and Prevention

Table 2. Input probabilities for the cost analysis of three HIV testing scenarios

Probabilities	*STD CT*	*STD Screening*	*ED Screening*
Patient is offered and accepts conventional HIV test[a]	0.78	0.97	0.26
Patient is offered and accepts rapid HIV test[a]	0.78	0.97	0.38
Patient receives pretest counseling[b]	1.00	0.00	0.00
Patient receives posttest counseling, first visit, rapid test, HIV+[c]	1.00	1.00	1.00
Patient receives posttest counseling, first visit, rapid test, HIV−[c]	1.00	1.00	1.00
Patient returns for posttest counseling, second visit, conventional test, HIV+[d]	0.45	0.45	0.50
Patient returns for posttest counseling, second visit, conventional test, HIV−[d]	0.31	0.31	0.28
Patient returns for posttest counseling, second visit, rapid test, HIV+[d]	0.98	0.98	0.65
Patient returns for posttest counseling, second visit, rapid test, HIV−[d]	0.00	0.00	0.00
Patient is true HIV+ (prevalence)[e]	0.01	0.01	0.01
EIA test sensitivity[f]	1.00	1.00	1.00
Conventional four-test confirmatory procedure sensitivity[g]	1.00	1.00	1.00
EIA test specificity[h]	0.998	0.998	0.998
Conventional four-test confirmatory procedure specificity[g]	1.00	1.00	1.00
Rapid test sensitivity[i]	0.996	0.996	0.996
Rapid two-test confirmatory procedure sensitivity[g]	1.00	1.00	1.00
Rapid test specificity[i]	0.9997	0.9997	0.9997
Rapid two-test confirmatory sequence specificity[g]	1.00	1.00	1.00

[a]STD CT and STD Screening scenarios: Lee JH, Mitchell B, Nolt B, Robbins B, Thomas MC, Branson BM. Targeted opt-in vs. routine opt-out HIV testing in an STD clinic. Abstract 153. Presented at the National HIV Prevention Conference; 1999 Aug 29–Sep 1; Atlanta. Our study assumed these probabilities did not vary between the conventional and rapid tests in the STD setting based on results from Spielberg F, Branson BM, Goldbaum GM, Lockhart D, Kurth A, Rossini A, et al. Choosing HIV counseling and testing strategies for outreach settings: a randomized trial. J Acquir Immune Defic Syndr 2005;38:348-55; and unpublished STD clinic data from one of the coauthors of that study. ED rapid test acceptance rate of 0.38 was derived from several sources: Lyss SB, Branson BM, Kroc KA, Couture EF, Newman DR, Weinstein RA. Detecting unsuspected HIV infection with a rapid whole-blood HIV test in an urban emergency department. J Acquir Immune Defic Syndr 2007;44:435-42; Silva A, Glick NR, Lyss SB, Hutchinson AB, Gift TL, Pealer LN, et al. Implementing an HIV and sexually transmitted disease screening program in an emergency department. Ann Emerg Med 2007;49:564-72; and Rapid HIV testing in emergency departments—three U.S. sites, January 2005–March 2006. MMWR Morb Mortal Wkly Rep 2007;56(24):597-601. The ED conventional test acceptance rate of 0.26 was derived as follows: In hospital inpatient and outpatient settings: Wurcel A, Zaman T, Zhen S, Stone D. Acceptance of HIV antibody testing among inpatients and outpatients at a public health hospital: a study of rapid versus standard testing. AIDS Patient Care STDs 2005;19:499-505 reported an acceptance rate of 0.412 for the conventional test and 0.594 for the rapid test. This study applied the proportionate difference between these probabilities (0.412/0.594=0.69) to the ED rapid test data to derive the conventional test acceptance rate: 0.69×0.38=0.26.

[b]For the STD CT scenario, this study assumed that everyone received pretest client-centered counseling. The STD Screening and ED Screening scenarios assumed no pretest counseling.

[c]Our study assumed that, with the rapid test, all patients stayed to receive their test results on the first visit.

[d]Kassler WJ, Dillon BA, Haley C, Jones WK, Goldman A. On-site, rapid HIV testing with same-day results and counseling. AIDS 1997;11:1045-51; Hutchinson AB, Branson BM, Kim A, Farnham PG. A meta-analysis of the effectiveness of alternative HIV counseling and testing methods to increase knowledge of HIV status. AIDS 2006;20:1597-604. The conventional test return rate of 0.45 for HIV-infected people in the STD CT and Screening scenarios was derived from Kassler et al. and did not include field outreach. The return rate of 0.50 for infected people under the conventional test in the ED scenario was derived as follows: The return rate of 0.67 reported by Hutchinson et al. included some follow-up phone calls. From Kassler et al., the overall return rate for infected people in STD clinics was 0.79, and the rate without field follow-up was 0.45. Using half of the 34-percentage point difference between these rates to account for phone call follow-up in emergency rooms, the 0.67 return rate was adjusted down to 0.50. The return rates of 0.31 and 0.28 for HIV-uninfected people under the conventional test procedure and of 0.98 and 0.65 for HIV-infected people under the rapid test procedure were derived from Hutchinson et al. Our study assumed that patients who tested negative with the rapid test did not have to make a second visit to the test site.

[e]Centers for Disease Control and Prevention (US). HIV counseling and testing at CDC-supported sites—United States, 1999–2004 [cited 2007 Apr 17]. Available from: URL: http://www.cdc.gov/hiv/topics/testing/reports.htm

[f]BioRad Laboratories. Package insert: Genetic Systems HIV-1/HIV-2 Plus O EIA. Redmond (WA): BioRad Laboratories; 2005.

[g]A confirmatory test procedure was assumed to have no false-positive or false-negative results. This is a standard assumption used in the literature.

[h]Bulterys M, Jamieson DJ, O'Sullivan MJ, Cohen MH, Maupin R, Nesheim S, et al. Rapid HIV-1 testing during labor—a multicenter study. JAMA 2004;292:219-23.

[i]Delaney KP, Branson BM, Uniyal A, Kerndt PR, Keenan PA, Jafa K, et al. Performance of an oral fluid rapid HIV-1/2 test: experience from four CDC studies. AIDS 2006;20:1655-60.

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STD = sexually transmitted disease

CT = counseling and testing

ED = emergency department

EIA = enzyme immunoassay

where the costs per HIV-infected patient receiving test results of the conventional and rapid testing strategies were equal, if they existed, were calculated.

RESULTS

Cost of HIV testing technologies

Table 3 presents component and total costs for a patient completing the conventional or rapid test procedure for each of the three scenarios. Costs for HIV-infected patients were higher than for uninfected patients due to the inclusion of multiple EIA tests, confirmatory Western blot tests, and the longer posttest counseling sessions. Overall costs of the rapid testing procedure were consistently higher than those of conventional testing because of more expensive test kits and, for patients who tested positive, the need for additional specimen collection and posttest counseling during both the initial and return visits. STD CT was more expensive than STD Screening due to the additional pretest counseling costs.

Cost of correct notification of results

Table 4 lists the cost per infected patient receiving his/her correct test result. This cost was lower in the STD Screening scenario than in the STD CT scenario, while the ED Screening scenario had the lowest overall cost values. In all three scenarios, the cost of HIV-infected patients receiving results was lower for rapid testing than for conventional testing.

Sensitivity analysis

The variables that had the largest effect on the costs of receiving results were the costs of the rapid test kit and the EIA reagent, HIV prevalence, and the return rate for infected patients after conventional testing. Rapid test kit costs ($9.00 in the base case) that are more than $10.20 (STD Screening scenario) or $10.80 (ED Screening scenario) would make the cost per patient receiving results higher using the rapid test compared with the conventional procedure in these scenarios. EIA reagent costs ($4.35 in the base case) that are less than $3.80 (STD Screening scenario) or $3.50 (ED Screening scenario) would also make the per-patient cost of receiving results higher for the rapid test procedure compared with the conventional test procedure.

In all three scenarios, the costs per infected patient receiving results for both conventional and rapid testing were much higher at the low prevalence rate of 0.001 (conventional/rapid: $42,328/$28,728 for STD CT; $18,939/$18,159 for STD Screening; and $17,181/$15,945 for ED Screening). However, the rapid test retained a cost advantage vs. the conventional test in promoting receipt of results through the entire range of prevalence values in the sensitivity analysis in all three scenarios.

The rapid test had a cost advantage vs. the conventional test in all scenarios if the return rate for infected patients after conventional testing was low. The threshold return rate above which the cost per HIV-infected patient correctly receiving test results was lower for the conventional compared with the rapid test was 0.67 for the STD CT scenario, 0.48 for the STD Screening scenario, and 0.55 for the ED Screening scenario.

Higher return rates for uninfected patients under the conventional test increased the cost of this testing procedure. However, the rapid test was more cost advantageous for all values of this variable in the STD CT and ED Screening scenarios and for a return rate greater than 0.23 in the STD Screening scenario. Changes in return rates for HIV-infected patients under the rapid test had no influence on the cost per HIV-infected patient receiving test results in any of the scenarios.

Higher acceptance rates for the rapid test only made the cost per HIV-infected patient notified of results even lower compared with the conventional test. In the ED Screening scenario, the per-patient cost of rapid testing and notification was lower than that for the conventional test as long as the probability of accepting the rapid test was greater than 0.15.

DISCUSSION

This study of the cost of HIV testing in different scenarios was based on updated cost estimates for EIAs and rapid tests, which have increased considerably since earlier analyses.[11,12] The second outcome measure, cost per HIV-infected patient correctly notified of his/her test results in various scenarios, is of policy interest to practitioners in STD clinics and emergency rooms around the country.

The costs of HIV screening depended on differences in testing technologies, counseling approaches, and HIV prevalence in the patient population. The complete rapid testing procedure was more expensive than conventional testing because of higher test kit costs and the additional counseling required for HIV-infected patients during both the first and second visits. However, when test acceptance and return rates in the different scenarios were taken into account, the expected cost of correctly notifying an HIV-infected patient of his/her results was consistently lower with the rapid test procedure than with conventional testing.

Of the three scenarios examined, the CT procedure in STD clinics was the most costly approach for

Table 3. Per-patient cost of conventional and rapid HIV testing procedures in three scenarios (in 2006 dollars)

Conventional test	*STD CT* HIV+	*STD CT* HIV−	*STD Screening* HIV+	*STD Screening* HIV−	*ED Screening* HIV+	*ED Screening* HIV−
Pretest counseling, first visit						
Value of provider time for pretest counseling	$6.91	$6.91	$0.00	$0.00	$0.00	$0.00
Value of provider time for collecting specimen	$1.56	$1.56	$1.56	$1.56	$1.56	$1.56
Value of administrative staff time	$3.52	$3.52	$0.00	$0.00	$0.00	$0.00
Total cost: pretest counseling	$11.99	$11.99	$1.56	$1.56	$1.56	$1.56
HIV antibody testing						
Value of lab technician time performing EIA test	$0.76	$0.38	$0.76	$0.38	$0.76	$0.38
Value of lab technician time performing WB test	$2.80	$0.00	$2.80	$0.00	$2.80	$0.00
Cost of EIA reagent	$13.05	$4.35	$13.05	$4.35	$13.05	$4.35
Cost of WB test kit	$35.11	$0.00	$35.11	$0.00	$35.11	$0.00
Total cost: HIV antibody testing	$51.72	$4.73	$51.72	$4.73	$51.72	$4.73
Posttest counseling, second visit						
Value of provider time for posttest counseling	$9.50	$3.20	$9.50	$3.20	$4.15	$0.35
Value of administrative staff time	$3.52	$3.52	$3.52	$3.52	$3.52	$3.52
Total cost: posttest counseling, second visit	$13.02	$6.72	$13.02	$6.72	$7.67	$3.87
Total provider cost: conventional test	$76.73	$23.44	$66.30	$13.01	$60.95	$10.16

Rapid test	*STD CT* HIV+	*STD CT* HIV−	*STD Screening* HIV+	*STD Screening* HIV−	*ED Screening* HIV+	*ED Screening* HIV−
Pretest counseling, first visit						
Value of provider time for pretest counseling	$6.91	$6.91	$0.00	$0.00	$0.00	$0.00
Value of provider time for collecting specimen	$2.42	$0.86	$2.42	$0.86	$2.42	$0.86
Value of administrative staff time	$3.52	$3.52	$0.00	$0.00	$0.00	$0.00
Total cost: pretest counseling	$12.85	$11.29	$2.42	$0.86	$2.42	$0.86
HIV antibody testing						
Value of provider time performing rapid test	$1.04	$1.04	$1.04	$1.04	$1.04	$1.04
Value of lab technician time performing WB test	$2.80	$0.00	$2.80	$0.00	$2.80	$0.00
Cost of rapid test kit	$9.00	$9.00	$9.00	$9.00	$9.00	$9.00
Cost of WB test kit	$35.11	$0.00	$35.11	$0.00	$35.11	$0.00
Total cost: HIV antibody testing	$47.95	$10.04	$47.95	$10.04	$47.95	$10.04
Posttest counseling, first visit						
Value of provider time for posttest counseling	$9.50	$3.20	$9.50	$3.20	$4.15	$0.35
Value of administrative staff time	$3.52	$3.52	$3.52	$3.52	$3.52	$3.52
Total cost: posttest counseling, first visit	$13.02	$6.72	$13.02	$6.72	$7.67	$3.87
Posttest counseling, second visit						
Value of provider time for posttest counseling	$9.50	$0.00	$9.50	$0.00	$4.15	$0.00
Value of administrative staff time	$3.52	$0.00	$3.52	$0.00	$3.52	$0.00
Total cost: posttest counseling, second visit	$13.02	$0.00	$13.02	$0.00	$7.67	$0.00
Total provider cost: rapid test	$86.84	$28.05	$76.41	$17.62	$65.71	$14.77

HIV = human immunodeficiency virus

STD = sexually transmitted disease

CT = counseling and testing

ED = emergency department

EIA = enzyme immunoassay

WB = Western blot

notifying HIV-infected patients of their test results. The per-patient costs of receiving test results with screening in STD clinics with either rapid or conventional tests were lower than those of the CT procedure, given the reduced counseling costs and higher test acceptance rates associated with screening.

The cost per infected patient receiving test results for the rapid test in the ED Screening scenario ($1,638) was the lowest for any of the settings (Table 4), demonstrating the potential utility of screening in this setting. These ratios were similar to those reported elsewhere. Walensky et al.[23] reported a cost of $4,850 per positive test result for routine screening at urgent care centers in Massachusetts. Golden et al.[24] cited costs per new case of HIV identified ranging from $3,120 in prisons to $56,000 for testing a general U.S. population, with most estimates varying between $3,500 and $6,500.

Although the per-patient costs of receiving test results were lower for rapid testing than for conventional testing in all settings, these estimates were very sensitive to the costs of the tests themselves. Only a 20% increase in the $9.00 cost of the rapid test kit in the screening settings would make the rapid test procedure testing and notification costs higher than those for the conventional procedure. Current retail costs of rapid test kits range from $8.00 to $18.00. Costs of less than $3.50 for an EIA test result would also give the cost advantage to the conventional procedure. The base case value of $4.35 was selected to represent an automated EIA procedure, but the cost per test result varied considerably with testing volume. Given volume discounts and the need to run multiple controls with each batch of specimens, large laboratories that perform EIAs with many specimens in each run report costs of less than $2.00 per test result, whereas smaller hospital laboratories, testing a mean of 12 specimens per day, report costs of more than $10.00 per EIA result. The actual charge facing a provider often differs substantially from the cost of the EIA and could be at least $10.00, which would then favor the rapid test procedure.

The model shows that rapid testing has a cost advantage when return rates for conventional test results by infected patients are low. In their analysis of HIV tests in various sites for the U.S. Preventive Services Task Force, Chou et al.[25] noted that rapid testing was associated with a higher rate of knowledge of serostatus than was conventional testing. In the current analysis, if less than 55% of those who tested HIV-positive in EDs returned for conventional test results, rapid testing would have the cost advantage. Although follow-up or outreach efforts for infected patients who fail to return for their test results are often necessary with conventional testing,[26,27] this study was unable to take these factors into account due to lack of relevant cost data.

The cost per HIV-infected patient receiving test results is highly dependent on HIV prevalence. These costs rise dramatically when HIV prevalence is extremely low because there are few HIV-infected patients to be identified. Coil et al.[28] reported estimates of HIV prevalence among ED patients ranging from zero to 14.0%. The lower-bound estimates of 0.2% and 0.7% by Mehta et al.[29] for an ED in an urban public medical center correspond to costs of approximately $8,000 at the 0.2% prevalence and $2,400 at the 0.7% prevalence in this analysis. The 5.4% prevalence observed by Kelen et al.[30] would result in costs ranging from $900 to $300 per HIV-infected patient. Clearly, the characteristics of the population treated in a given ED can have a major impact on the costs of the screening procedures.

The cost results also depend on the value of providing preliminary positive rapid test results in the ED setting. If doing so is not considered useful (an outcome value of 0.00 rather than 0.99), the cost for an HIV-infected person receiving test results for the rapid test increases from the baseline value of $1,638 to $2,511 because of a large proportionate increase in testing costs with no increase in effectiveness. Although data on changes in risk behavior after receipt of a preliminary positive HIV test result are not yet available, research shows that patients who receive such results are much more likely to learn their confirmatory test results.[26]

Table 4. Cost per HIV-infected patient receiving test results in three HIV testing scenarios (in 2006 dollars)

	STD CT		*STD Screening*		*ED Screening*	
	Conventional test	*Rapid test*	*Conventional test*	*Rapid test*	*Conventional test*	*Rapid test*
Cost per HIV-infected patient	$4,334	$2,925	$1,995	$1,868	$1,807	$1,638

HIV = human immunodeficiency virus

STD = sexually transmitted disease

CT = counseling and testing

ED = emergency department

Increased testing in the ED setting is likely to have a substantial effect on minority communities, given the demographics of patients seeking care in this setting. In a study of routinely offered HIV and STD screening to as many age-eligible patients as possible in an urban nonprofit hospital ED, Silva et al.[13] found that patients treated during the study hours were primarily women (56.0%) and non-Hispanic black (61.7%) or Hispanic (30.8%). More than 75% of the patients were black in a study of ED testing in a Midwestern urban teaching hospital in a low-prevalence area,[27] while significant majorities of black and Hispanic patients were tested in three demonstration projects in EDs in Los Angeles, New York City, and Oakland, California.[14]

Limitations

This study, which updated the provider costs of screening for HIV infection in various settings, drew its input parameters from a substantial number of time and motion cost collection studies, meta-analyses, and CDC demonstration projects. However, the study was subject to several limitations. There may be longer-term effects of counseling and testing compared with screening that could not be included in this analysis. Counseling might affect the behavior of either infected or uninfected patients, influence their likelihood of returning for test results, or influence whether they are likely to enter into care. Meta-analyses have shown that information-based counseling increases safe behaviors and decreases risky behaviors among HIV-infected people, but there is typically a lesser or no effect among uninfected people included in these studies.[31] Structured, theory-based, client-centered counseling has been shown to reduce risk behaviors and STD infections among HIV-uninfected people in an STD clinic,[18] but its cost may be higher than that considered in the current analysis, and its use may result in a smaller number of patients being tested in busy ED settings.[14]

This study did not attempt to assign any reduction in value attributable to preliminary false-positive results. However, the meta-analysis by Hutchinson et al.[10] found that preliminary false-positive results are relatively rare (0.6%) with rapid testing, so this would have little effect on this analysis conducted from the provider perspective.

This study also did not attempt to address the costs associated with follow-up of HIV-infected people who failed to return for their test results, or of facilitating entry into care following a positive HIV test. Although this is an important issue, data are sparse, cost estimates of the process vary widely, and these costs are often incurred by other institutions. Kassler et al.[26] showed that 30% of patients who tested positive after conventional testing required field follow-up to notify them of their test results, compared with 3% of patients who received a preliminary positive rapid test result. By extension, people who receive immediate results from rapid tests may be more likely to engage in follow-up care than the large proportion of people who fail to receive their results after conventional testing.

CONCLUSION

In summary, the costs for both the conventional and rapid testing procedures and the cost per HIV-infected patient receiving test results were lower in the STD Screening scenario than in the STD CT scenario. The cost per infected patient receiving results was lower for the rapid test procedure than for the conventional test in all scenarios, and was comparable to those in other analyses, even at low HIV prevalence. Thus, HIV screening in health-care settings consistent with the September 2006 CDC recommendations is more economically feasible than the traditional CT approach recommended previously. Screening in these settings is likely to have substantial benefits for minority communities, where a large proportion of people rely on emergency rooms and STD clinics as their source of medical care.

Costs of the conventional and rapid tests, HIV prevalence, and return rates after conventional testing are the most important factors in determining the overall costs of the HIV screening strategies. These variables can differ substantially across settings. However, given the baseline input values from HIV testing programs in these settings, the current analysis makes a strong case for the increased use of rapid testing and the expansion of HIV screening in health-care settings.

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